

Contribution of National Near Real Time MODIS Forest % Maximum NDVI Change Products to the U.S. ForWarn System

Authors: J. Spruce, W. Hargrove, J. Gasser, J. Smoot, P. Kuper

This presentation reviews the development, integration, and testing of Near Real Time (NRT) MODIS forest % maximum NDVI change products resident to the USDA Forest Service (USFS) [ForWarn System](#). ForWarn is an Early Warning System (EWS) tool for detection and tracking of regionally evident forest change, which includes the [U.S. Forest Change Assessment Viewer](#) (FCAV) (a publically available on-line geospatial data viewer for visualizing and assessing the context of this apparent forest change). NASA Stennis Space Center (SSC) is working collaboratively with the USFS, ORNL, and USGS to contribute MODIS forest change products to ForWarn. These change products compare current NDVI derived from expedited eMODIS data, to historical NDVI products derived from MODIS MOD13 data. A new suite of forest change products are computed every 8 days and posted to the ForWarn system; this includes three different forest change products computed using three different historical baselines: 1) previous year; 2) previous three years; and 3) all previous years in the MODIS record going back to 2000. The change product inputs are maximum value NDVI that are composited across a 24 day interval and refreshed every 8 days so that resulting images for the conterminous U.S. are predominantly cloud-free yet still retain temporally relevant fresh information on changes in forest canopy greenness. These forest change products are computed at the native nominal resolution of the input reflectance bands at 231.66 meters, which equates to ~ 5.4 hectares or 13.3 acres per pixel. The Time Series Product Tool, a MATLAB-based software package developed at NASA SSC, is used to temporally process, fuse, reduce noise, interpolate data voids, and re-aggregate the historical NDVI into 24 day composites, and then custom MATLAB scripts are used to temporally process the eMODIS NDVIs so that they are in synch with the historical NDVI products. Prior to posting, an in-house snow mask classification product is computed for the current compositing period and integrated into the change images to account for snow related NDVI drops. The supplemental snow classification product was needed because other available QA cloud/snow mask typically underestimates snow cover. MODIS true and false color composites were also computed from eMODIS reflectance data and the true color RGBs are also posted on ForWarn's FCAV; this data is used for assessing apparent occasional quality issues on the change products due to residual unmasked cloud cover. New forest change products are posted with typical latencies of 1-2 days after the last input eMODIS data collection date for a given 24 day compositing period.

Once in the FCAV, these current forest change products can be visually compared to several geospatial data sets depicting forest disturbances, i.e., from aerial detection surveys (ADS), current and historical fires, tornado damage locations, land cover, climate parameters, and topographic variables. The FCAV includes current as well as retrospective forest change products available for 2010 to present. Forest change products have been validated retrospectively and in rapid response "now cast" mode by using available geospatial reference data, as well as news accounts and communications with federal and state agency forest health specialists. Completed retrospective studies include assessment of MODIS forest change product ability to detect regional disturbances from (1) gypsy moth defoliation and (2) hurricane induced damage. A case study currently underway is assessing MODIS forest change products for detecting disturbance and mountain pine beetle induced forest mortality in the Rocky

Mountains. Validation studies like these compare MODIS forest change products to higher spatial resolution satellite and in-situ data. Apparent disturbances on current NRT change products are assessed qualitatively by comparing them to Landsat-based RGBs and change detection products, and to historical disturbance data, news accounts, and communications with Forest Health Monitoring (FHM) experts. Fortunately, current Landsat data products are posted shortly after each collection date. However, the current lack of fresh Landsat 5 data impedes the use of Landsat for assessing current MODIS forest change products. When the ForWarn/FCAV change products show unusual, potentially detrimental disturbances (i.e. anomalies), map displays can be saved as an URL and emailed to perspective end-users, i.e. those conducting ADS works, entomologists, pathologists, and others state and federal forest health specialists. In some cases, more expedited MODIS forest change products have also been computed to aid rapid response damage assessment surveys (e.g., for the April 2011 tornado outbreak in the southeastern US and for 2011 spring flooding in coastal Louisiana).

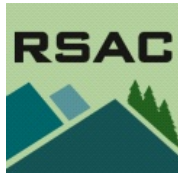
FHM specialists have used these change products to help assess regionally evident conterminous forest disturbances from multiple biotic and abiotic damage agents. These products have been utilized to help evaluate insect defoliation disturbance in the spring, summer, and fall; and have also been used to help assess areas where western U.S. bark beetle have induced extensive mortality . Use of multiple change products based on multiple baselines enhances assessment of disturbance vintage and persistence. Change based on previous year's baseline is useful for evaluating new change hotspots and the intensification of change, versus the previous year. Use of change products based on a given multiyear base line can help improve detectability and characterization of forest change due to annual insect defoliation, like what can occur in coastal Louisiana swamp forests. While these change products do not depict forest disturbances at the Landsat spatial resolution, they do provide a general indication of the location and relative intensity of forest disturbances that can be conveyed to the FHM so that more intensive aerial and field surveys can be produced. These change products have been used to help focus more intensive forest health aerial and field surveys. The high temporal resolution of the near daily MODIS Aqua and Terra data offers an unprecedented way to regionally monitor forest change throughout the growing season and calendar year.

Future work will include additional product validation studies as well as developing methods to improve the quality, use, and automated computation of these products.



Contribution of National Near Real Time MODIS Forest % Maximum NDVI Change Products to the U.S. ForWarn System

Presented to the 2012 ForestSat Meeting by:
Joseph Spruce, Computer Sciences Corporation (CSC)
William Hargrove, USDA Forest Service
Gerald Gasser, Lockheed Martin
James Smoot, CSC
Philip Kuper, CSC



Introduction



- U.S. forests occupy ~751 million acres (~1/3 of total land)
- Several biotic and abiotic damage agents disturb, damage, kill, and/or threaten these forests
- Regionally extensive forest disturbances can also threaten human life and property, bio-diversity and water supplies
- Timely regional forest monitoring products are needed to aid forest monitoring and management work at finer scales
- Daily MODIS data provide a means to monitor regional forest disturbances across the country on a weekly basis
- In response, the USFS and NASA began collaborating in 2006 to develop a Near Real Time (NRT) forest monitoring capability, based on MODIS NDVI data, as part of a national forest threat Early Warning System (EWS)

Rationale for EWS: Healthy Forest Restoration Act of 2003

Stennis Space Center



- The EWS was mandated by the Healthy Forest Restoration Act of 2003, Section VI
 - *“In carrying out the program, the Secretary (of Agriculture) shall develop a comprehensive early warning system for potential catastrophic environmental threats to forests”*
- The EWS is to contribute to a forest inventory and monitoring program for aiding environmental threat detection and response
 - *Threats include insects, diseases, invasive species, fire, weather, storm damage, and forest loss and degradation*
 - *ForWarn contributes current regional monitoring to this EWS*

U.S. ForWarn System for Regional Forest Disturbance Monitoring

Stennis Space Center



<http://forwarn.forestthreats.org>

FW Home | ForWarn

forwarn.forestthreats.org

CONTACT US

Search

ForWarn
Satellite-Based Change Recognition and Tracking

Home Overview News Highlights Data Support

Tornadoes scar the South

Forests across northern Mississippi, Alabama and Georgia were hard hit by tornadoes in April, 2011. Tree mortality was often severe for areas in the direct path of these storms as shown in this photo from near Lake Burton in the Chattahoochee...

[read more »](#)

What is ForWarn?

ForWarn is a satellite-based forest disturbance monitoring system for the conterminous United States. It delivers new forest change products every eight days and provides tools for attributing abnormalities to insects, disease, wildfire, storms, human development or unusual weather. Archived data provide disturbance tracking across all lands since 2000. Interactive maps are accessible via the [Forest Change Assessment Viewer](#). Read more about ForWarn [here](#).

Recent News

Official ForWarn News Release Now Available

03/21/2012 - 09:25 The official news release from the USDA Forest Service and NASA announcing ForWarn is now available for download!
[USDA FS AND NASA JOINT PRESS RELEASE 03 15 12.DOC](#)

Introducing the Pest Proximity Database

02/17/2012 - 10:40 The new Pest Proximity Database, now built into the Forest Change Assessment Viewer, helps determine which insects and disease agents are most likely to have been responsible for new forest...

[more news »](#)

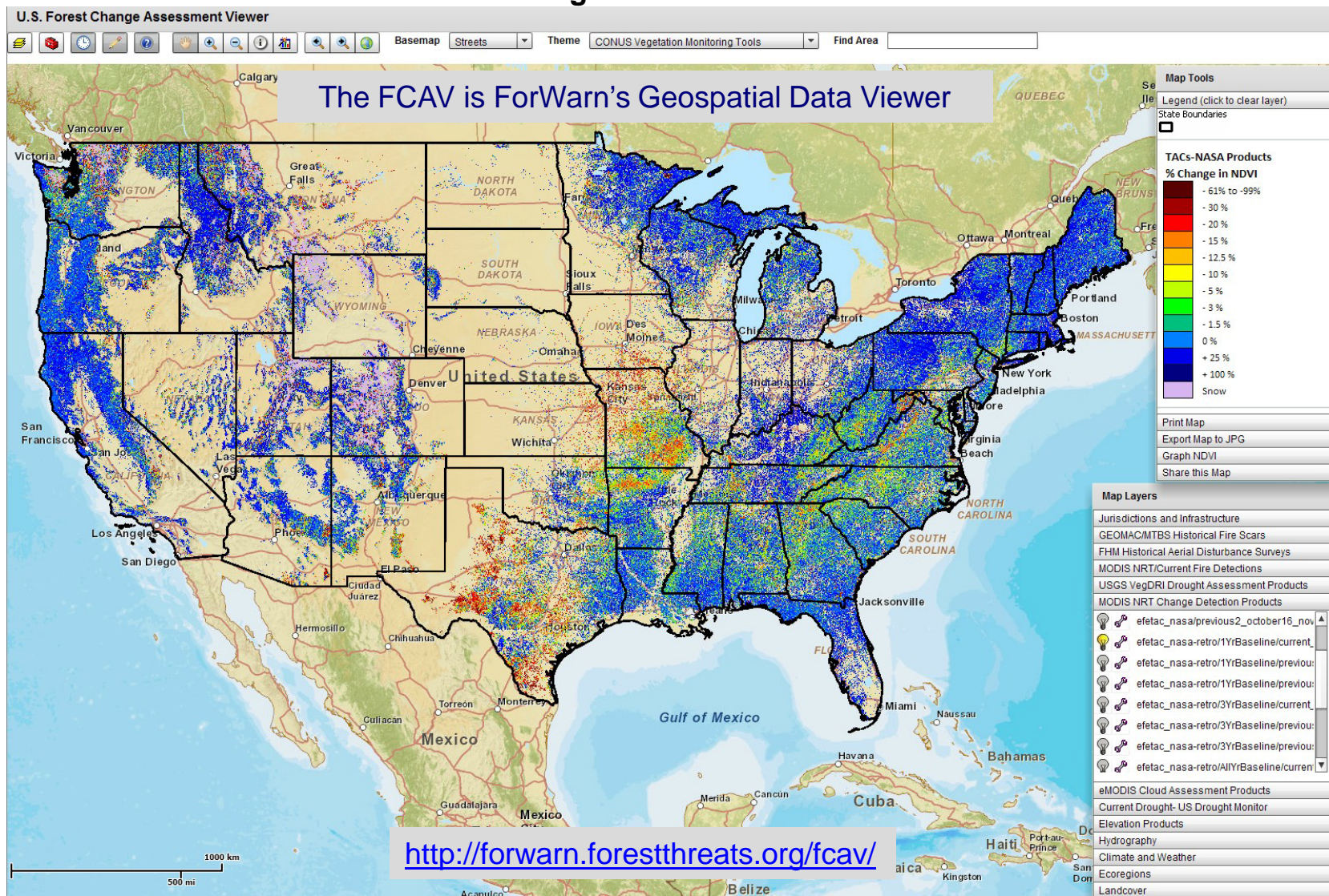
USDA Forest Service EFETAC WWETAC Policies and Links Privacy Policy Accessibility Statement FOIA Non-discrimination Statement White House usa.gov Log In

U.S Forest Change Assessment Viewer (FCAV) - New Products Every 8 Days

Stennis Space Center



2011 Forest % NDVI Change versus Previous Year for November 1 - 24



Objectives for ForWarn's NRT MODIS Forest Disturbance Detection Products

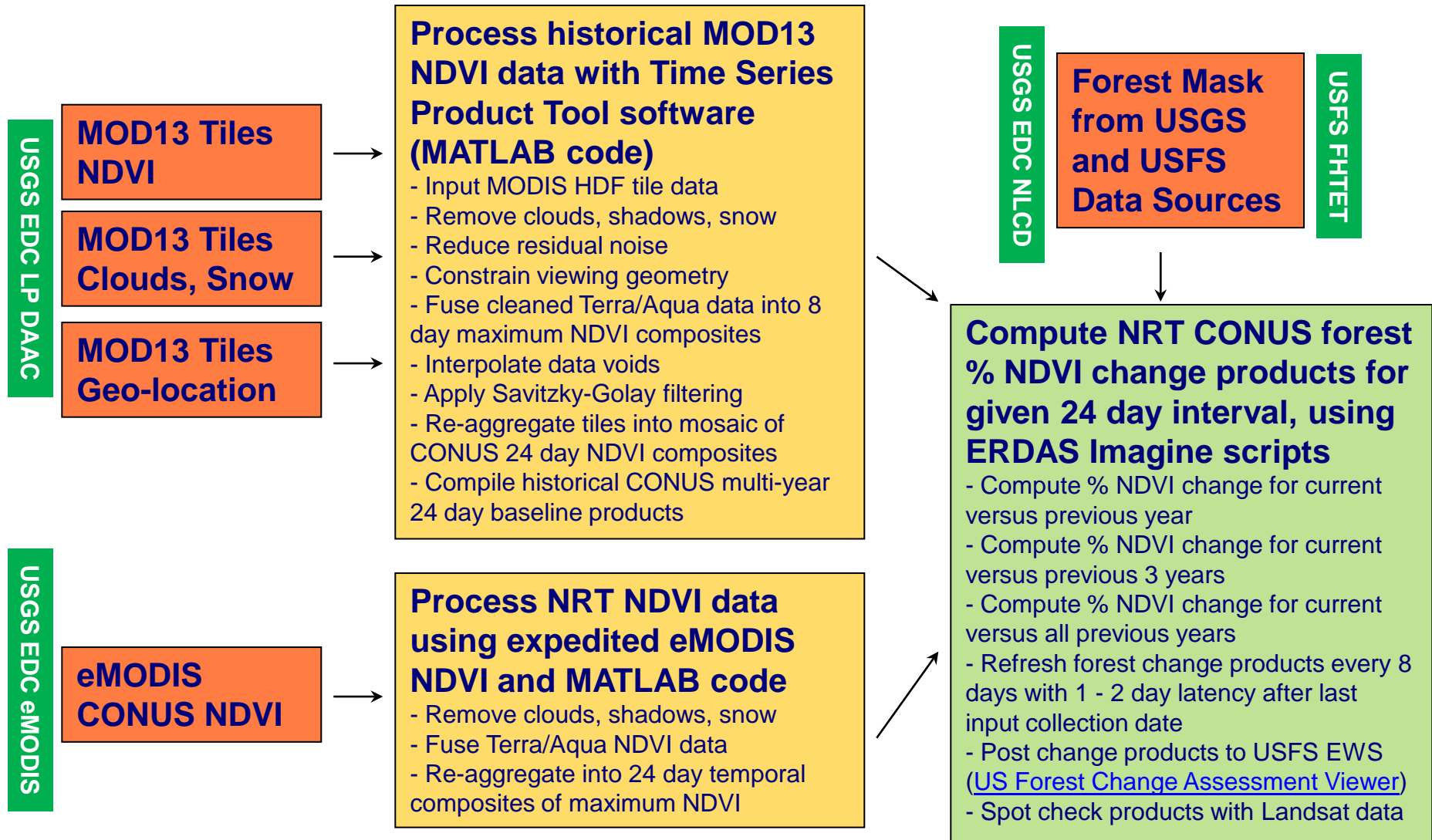
Stennis Space Center



- **Objective 1** – Contribute nationwide weekly NRT MODIS %NDVI forest disturbance detecting products to USFS EWSs
 - *U.S. ForWarn System (USFS EFETAC and WWETAC)*
 - *U.S. Forest Disturbance Mapper (USFS FHTET)*
- **Objective 2** – Conduct in-season rapid preliminary assessments of NRT MODIS %NDVI change products for detecting regional forest disturbances
- **Objective 3** – Perform product validations for specific damage events and geographic regions

Processing Method for ForWarn's MODIS % NDVI Change Products

Stennis Space Center



Series 1 – Examples of ForWarn MODIS Change Products With Regionally Evident Abiotic Forest Disturbances

*2011 Tornadoes
in Alabama and Mississippi*



Source: NOAA

*2012 High Park Fire in
Colorado Front Range*



Source: NASA

*2012 Hail Damage
Asheville Watershed, NC*



Source: USFS

*2011 Drought in Texas,
and Adjacent States*



Source: NOAA

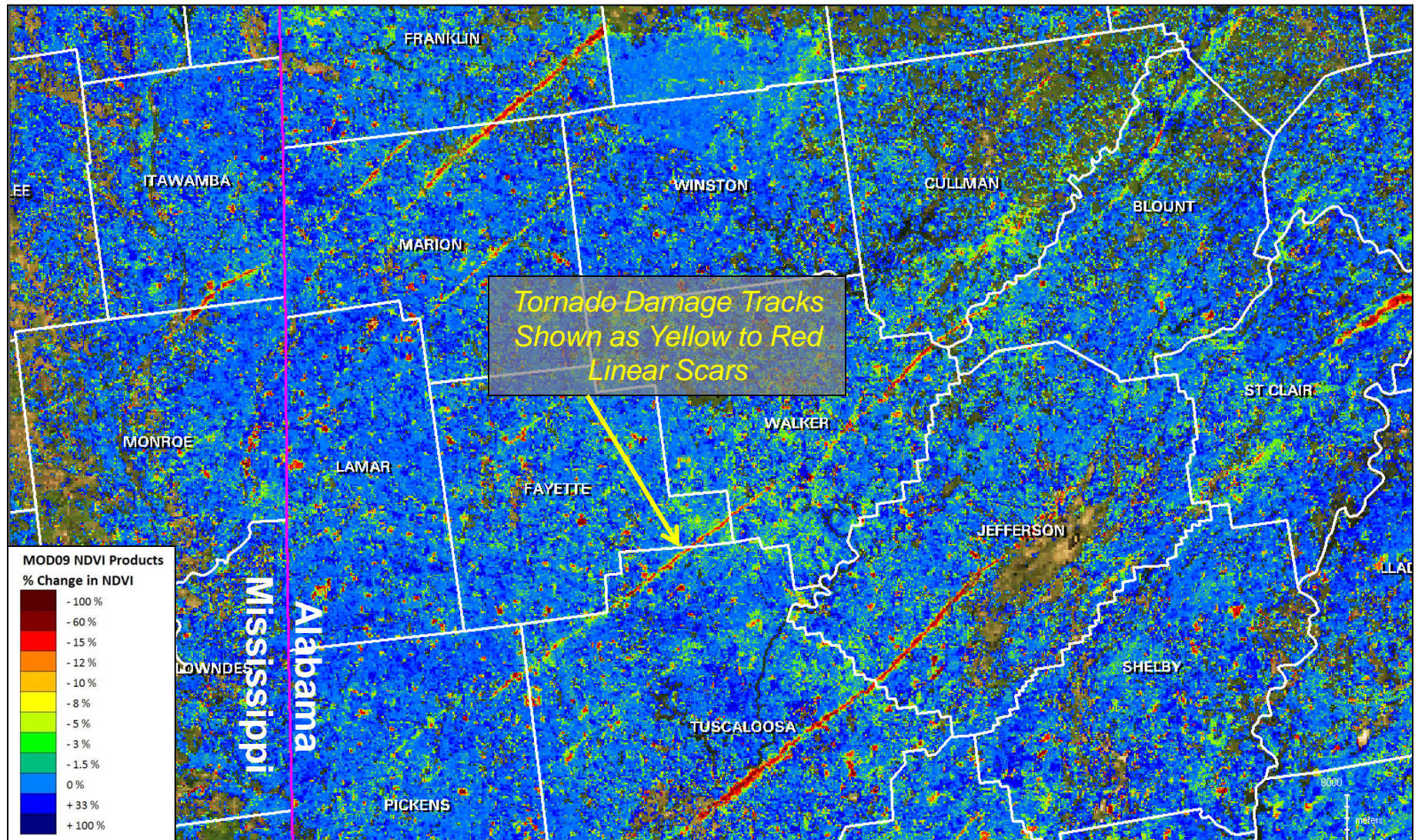
MODIS View of April 27, 2011

Tornadoes in Mississippi and Alabama

Stennis Space Center



Forest %NDVI Change for May 1-24, 2011 versus 2010 – Counties in White

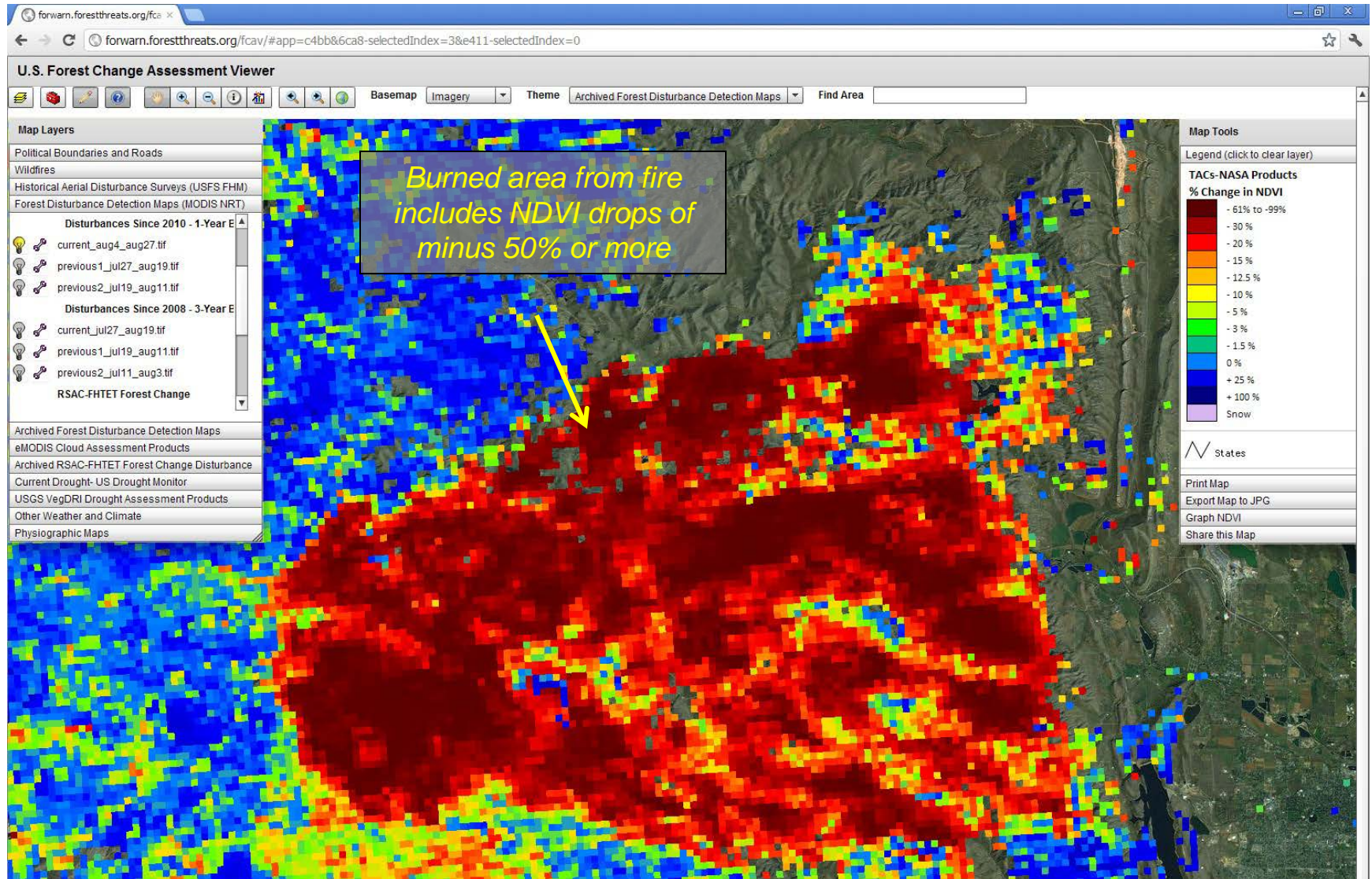


MODIS View of 2012 High Park Fire in Colorado Front Range

Stennis Space Center



Forest % NDVI Change for August 4 – 27, 2012 versus 2011



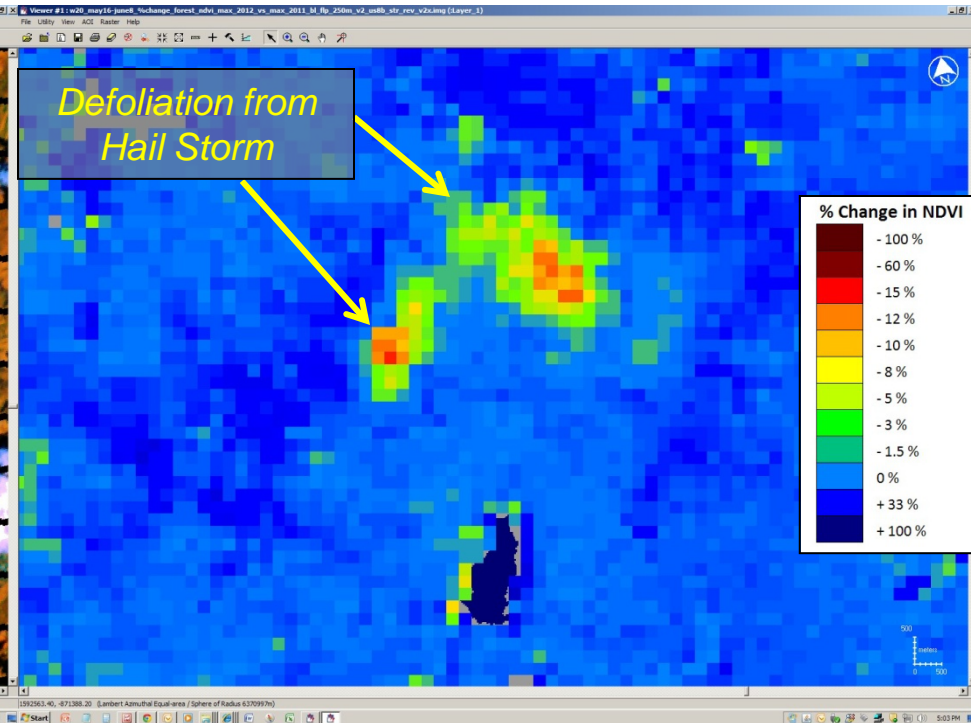
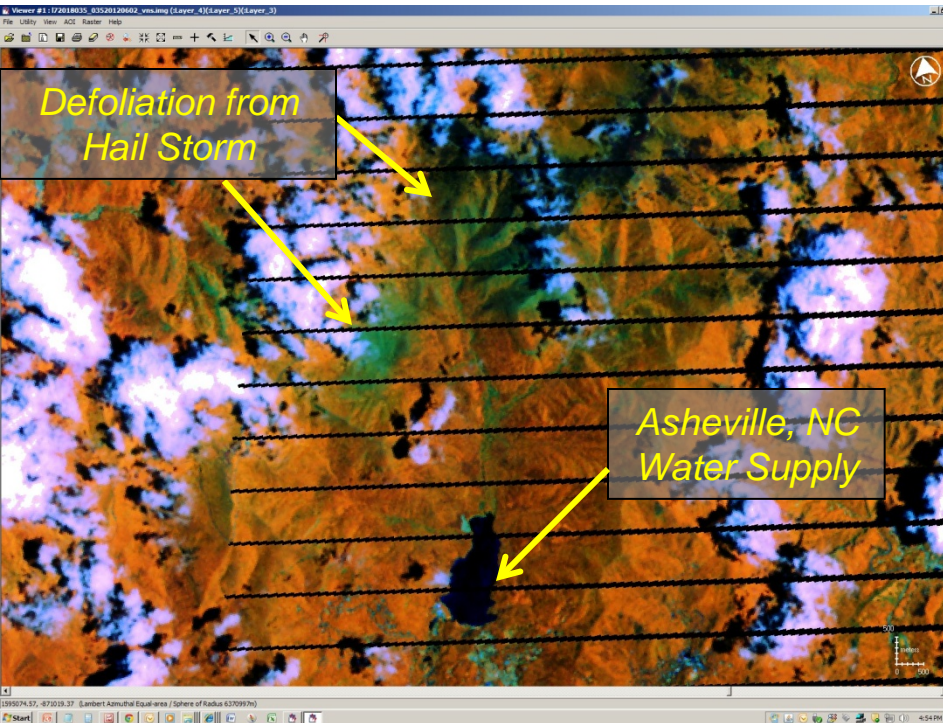
MODIS View of 2012 Hail Damage to Asheville, North Carolina Watershed

Stennis Space Center



Landsat 7 False Color RGB from 6/2/2012

MODIS % NDVI Change for 5/16 to 6/8/2012 vs. 2011



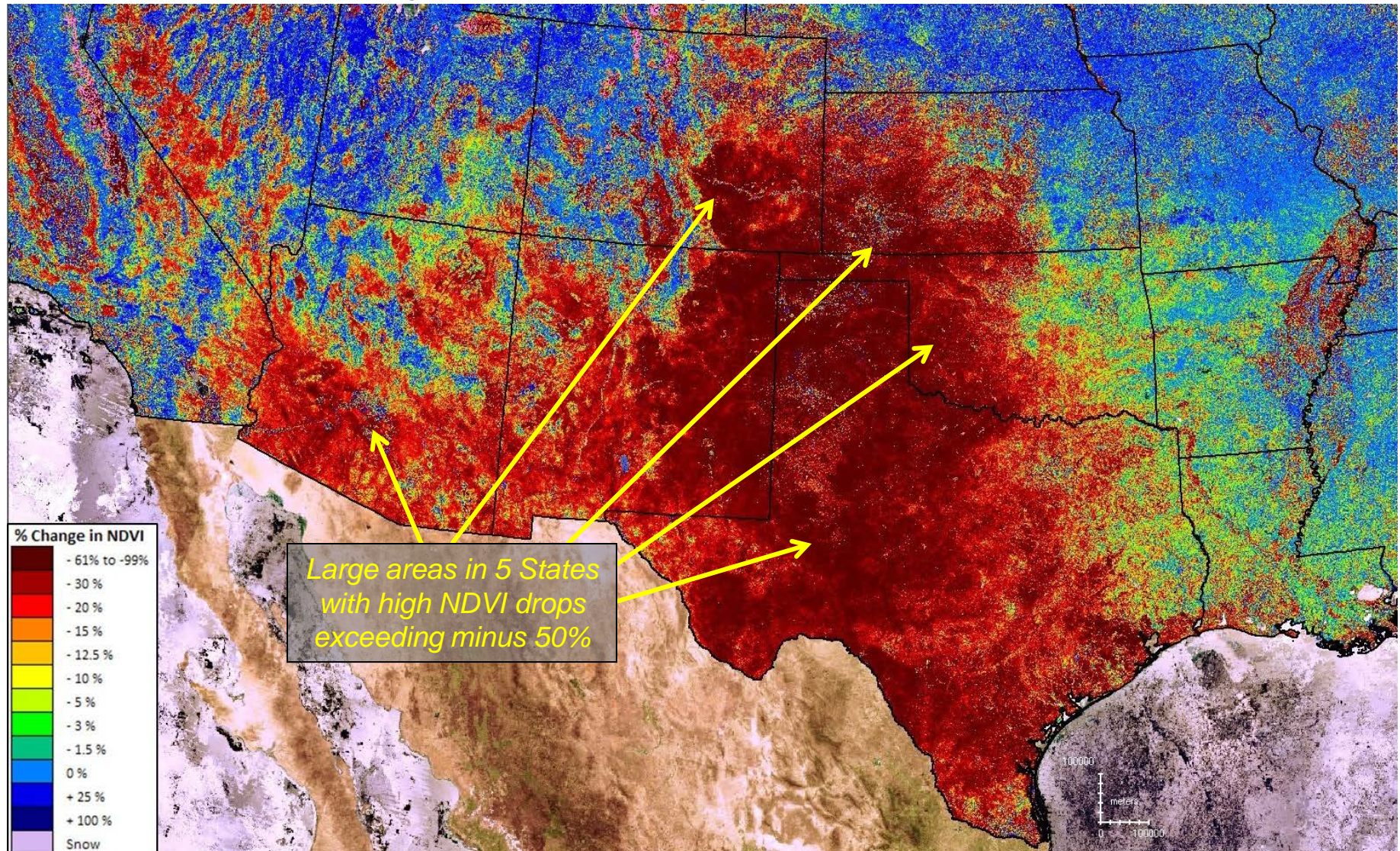
Area Field Checked 6/14/2012

MODIS View of 2011 Drought in Texas and Adjacent States

Stennis Space Center



Land %NDVI Change for June 18 through July 11 of 2011 versus 2003-2010



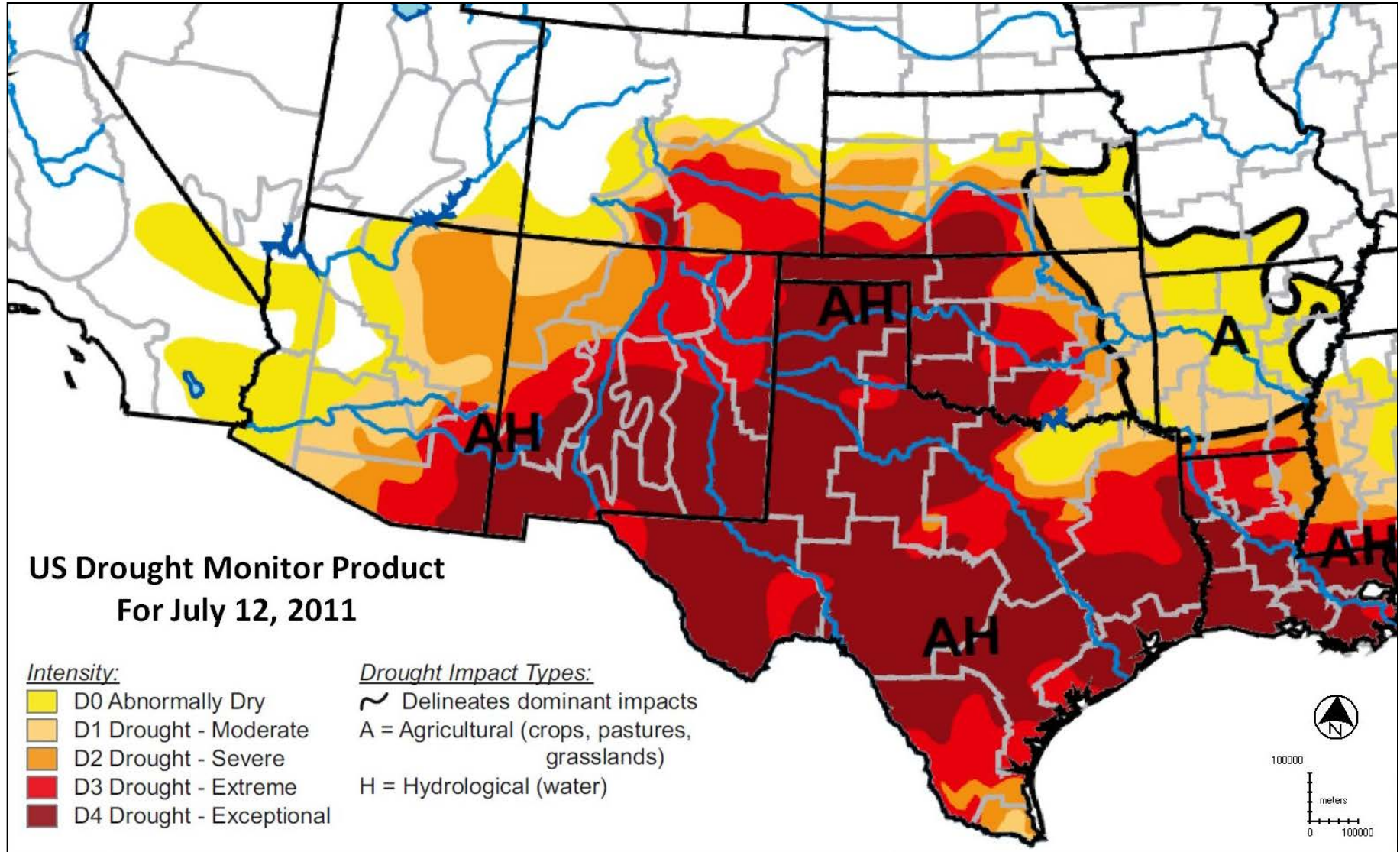
U.S. Drought Monitor View of 2011

Drought in Texas and Adjacent States

Stennis Space Center



U.S. Drought Monitor Product for July 12, 2011



Series 2 – Examples of ForWarn MODIS Change Products Showing Regionally Evident Biotic Forest Disturbances

2012 Spring Defoliation in Louisiana Swamps from Caterpillars



Source: LSU

2012 Summer Spruce Beetle Mortality in Rio Grande NF of Colorado



Source: CSU

2011 Summer Budworm Defoliation in Washington State



Source: USFS

2011 Fall Defoliation in Pennsylvania From Fall Webworm



Source: Texas FS

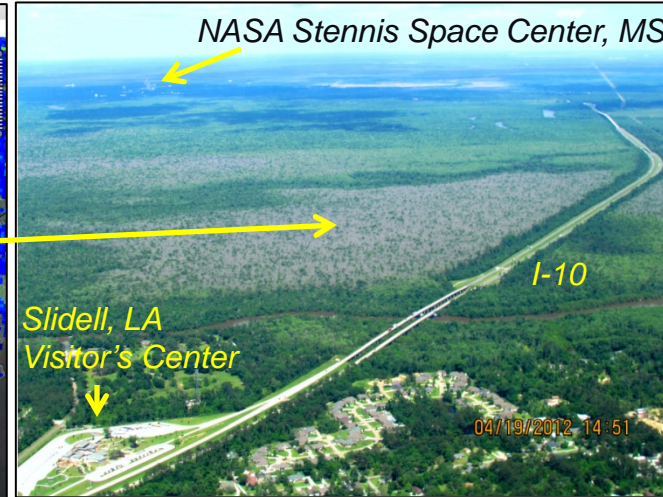
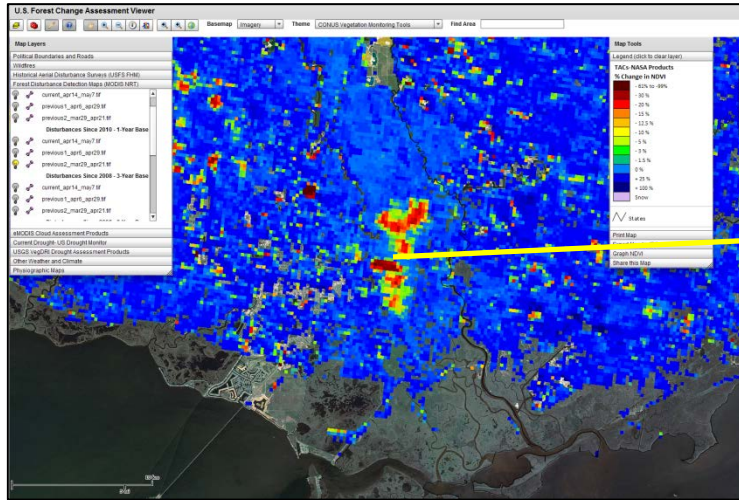
MODIS View of 2012 Wetland Forest Defoliation in Coastal Louisiana

Stennis Space Center



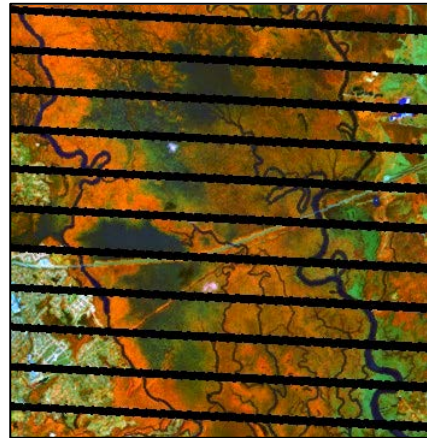
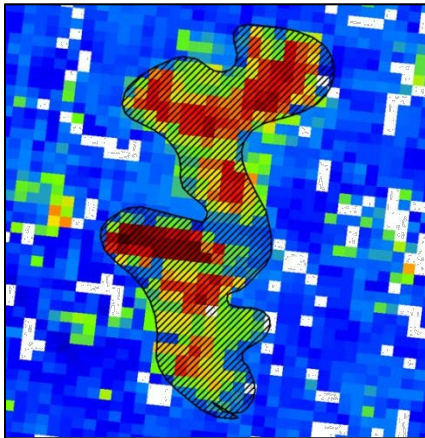
*MODIS Forest % NDVI Change Product
(Date Ending 4/21 for 2012 versus 2011)*

*Aerial Oblique Below Acquired by DAF
(Days After Initial ForWarn Notification)*



*2012 MODIS Product with LDAF 2012
Aerial Survey Polygon from 4/19/2012*

*Landsat False Color RGB Image from
4/12/2012 (Healthy Forest Orange/Brown)*



*MODIS products showing locations of insect
defoliated swamp forests – were used to aid aerial
detection surveys by LDAF and the USFS*

Pearl river, LA photos of forest tent caterpillar and defoliation

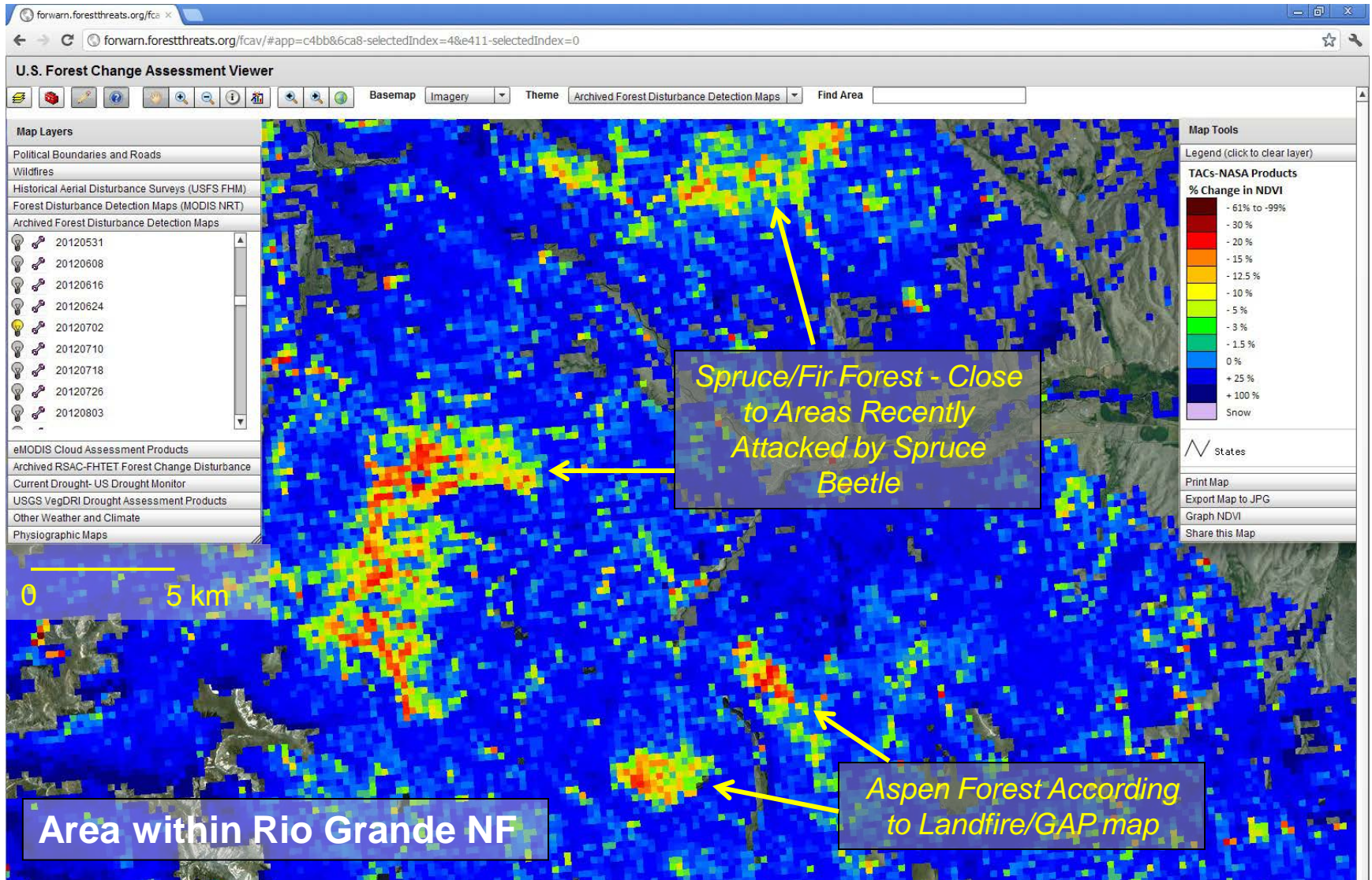


MODIS View of Potential New 2012 Spruce Beetle Mortality in Colorado

Stennis Space Center



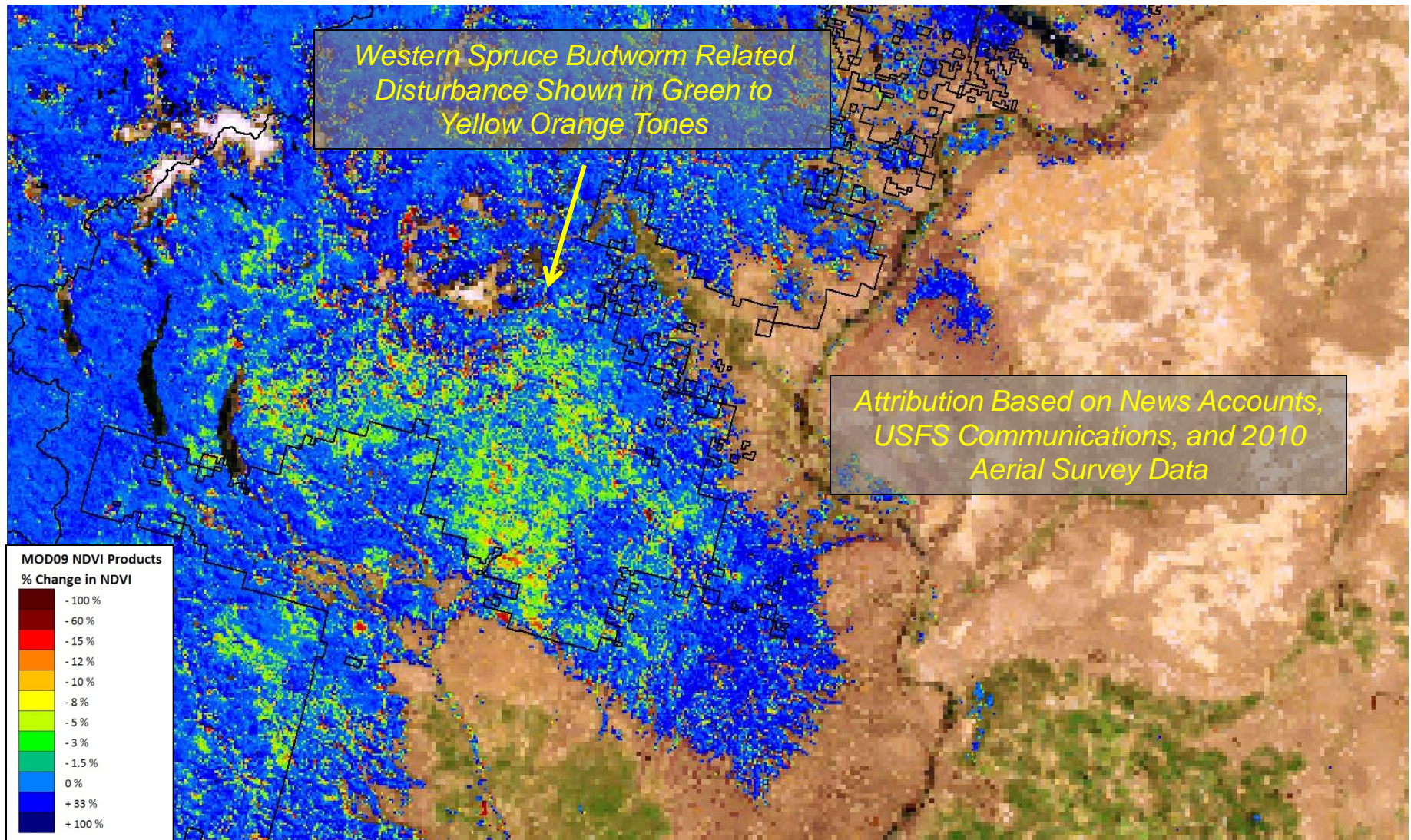
Forest % NDVI Change for Date Ending July 2 of 2012 versus 2011



MODIS View of Apparent Spruce Budworm Defoliation in Washington

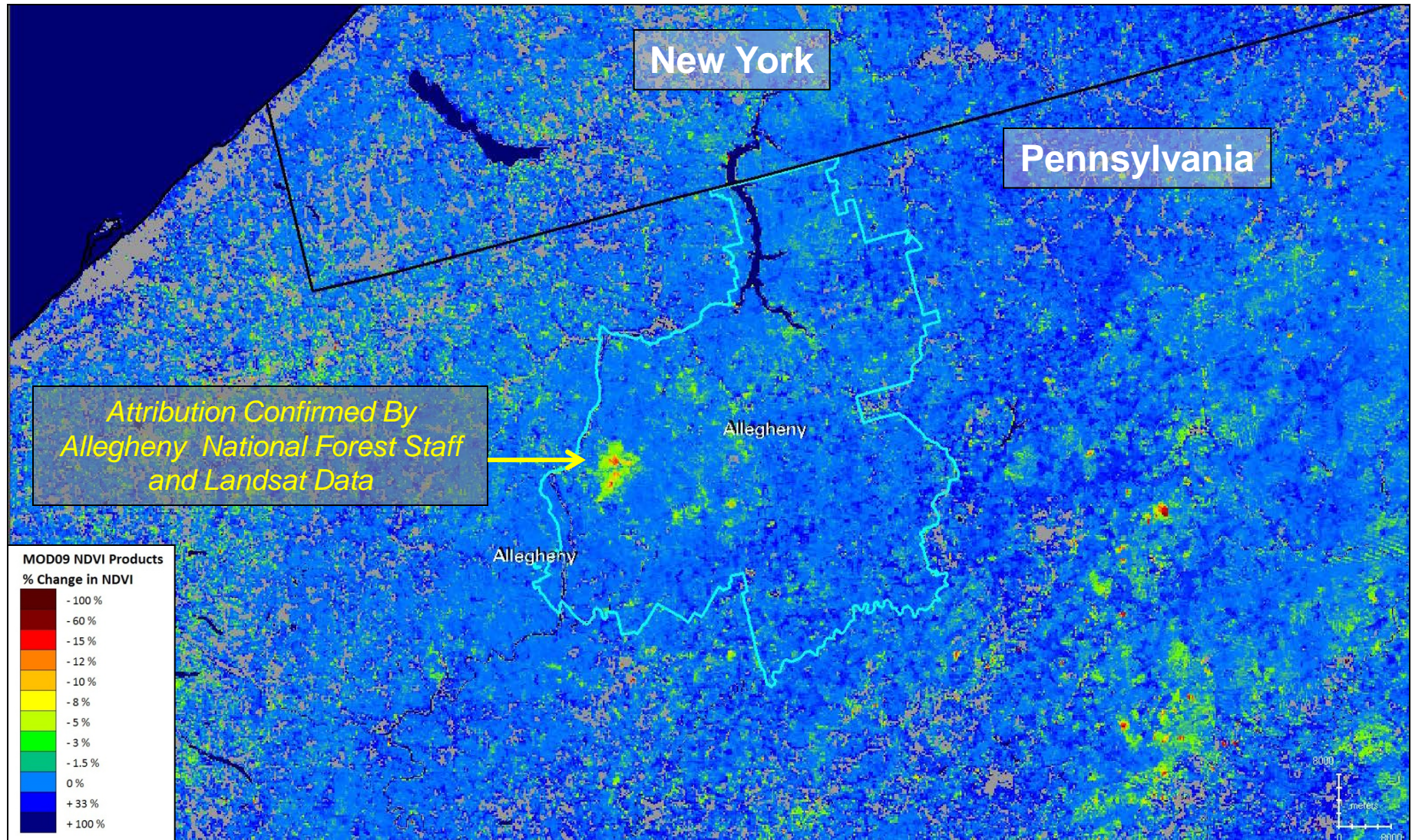
Stennis Space Center

Forest %NDVI Change for 8/21 through 9/13 of 2011 versus 2008-2010 – National Forests in Black



MODIS View of Fall Webworm Defoliation in Pennsylvania

Stennis Space Center



Comments on Example Results for 2011-2012

Stennis Space Center



- NRT MODIS CONUS forest change products showed multiple regional forest disturbances
 - *New disturbances were best detected using the previous year NDVI as the baseline*
 - *Multiyear disturbance events were best assessed using all three historical NDVI baselines (previous 1, 3 and all years)*
- Detected disturbances were assessed with news accounts, aerial disturbance surveys, fire maps, and Landsat data
- ForWarn disturbance detection results were conveyed to Federal and State forestry specialists for aiding forest health monitoring

Final Remarks



- Since 2010, NRT MODIS % NDVI change products have been produced for the U.S. every 8 days
- These were usually posted on the ForWarn FCAV within 1-2 days after the last collection date
- These products show regionally evident multi-seasonal biotic or abiotic disturbance to both conifer and hardwood forests across the U.S.
- Future work
 - ForWarn FCAV upgrade – new functions and products
 - MODIS change product development, revision, and validation
- For more information, email joseph.p.spruce@nasa.gov

Project Publications

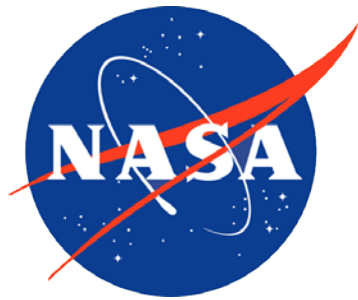


W.W. Hargrove, J.P. Spruce, G.E. Gasser, and F.M. Hoffman, 2009, Toward a national early warning system for forest disturbances using remotely sensed canopy phenology. *Photogrammetric Engineering & Remote Sensing* 75:1150-1156.

McKellip, R., D. Prados, R. Ryan, K. Ross, J. Spruce, G. Gasser, and R. Greer, 2008: Remote-sensing time series analysis, a vegetation monitoring tool, *NASA Tech Briefs* 32(4):63-64.

Ramsey E., J. Spruce, A. Rangoonwala, Y. Suzuoki, J. Smoot, and J. Gasser, and T. Bannister, 2011: Daily MODIS data trends of hurricane-induced forest impact and early recovery, *Photogrammetric Engineering and Remote Sensing*, 77 (11):133-143.

Spruce, J.P., S. Sader, R. E. Ryan, J. Smoot, P. Kuper, K. Ross, D. Prados, J. Russell, G. Gasser, R. McKellip, and W. Hargrove, 2011, Assessment of MODIS NDVI time series data products for detecting forest defoliation from gypsy moth outbreaks, *Remote Sensing of Environment*, 115:427–437.



Participation in this work by Computer Sciences Corporation, Inc., was supported by NASA at the John C. Stennis Space Center, Mississippi, under contract NNS10AA35C. Project funding was provided to NASA by the USDA Forest Service Eastern and Western Threat Assessment Centers.